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EVALUATION OF SOUTHERN PINE BEETLE INFESTATION GROWTH AND  
PROLIFERATION IN CUT-AND-LEAVE AND UNTREATED AREAS

by

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TITLE. Evaluation of Southern Pine Beetle Infestation Growth and Proliferation in Cut-and-Leave and Untreated Areas.

JUSTIFICATION. Operational suppression projects for reducing southern pine beetle (SPB) losses are based on a careful evaluation of the insect and selection of a suppression method. In the South, three major methods are currently recommended: (1) removal of insect-infested trees, (2) pile and burn of infested trees, and (3) chemical treatment of infested trees. Salvage removal of infested pines currently is the most widely used suppression method. Not only are beetles moved from the woods in infested trees, but some recovery of losses through utilization of infested trees is achieved. There are, however, some problems with attempting prompt salvage. Many times inclement weather conditions, inaccessibility, or a depressed lumber or pulpwood market all but stop a salvage-removal project.

Of the other suppression methods, cut and spray is being used only on a selective basis, whereas pile and burn is not widely used because of the fire danger hazard. These techniques are costly to apply and are detrimental to southern pine beetle parasites and predators. Alternative methods are needed to control the southern pine beetle that are more economical, more efficacious, and less harmful to the environment.

The cut and leave method, being used operationally by the Texas Forest Service, indicates considerable promise for use as a suppression technique. Other States have also expressed an interest in using this method. The Forest Service, USDA, will not recommend implementation of the cut-and-leave method until its effectiveness has been adequately demonstrated.

The previous cut-and-leave and cut-and-top evaluation (Hertel et al.) funded by the Program evaluated the effects on spot growth, spot proliferation, and within-tree SPB populations. There were no significant differences between treatments, primarily because of declining southern pine beetle populations. Even if the results had been definitive, it was known that a follow-up study would be needed to determine the effects on an area basis. It is still strongly viewed that the cut-and-leave method has high potential as a suppression tool and immediate follow-up on Hertel's (1977) study is needed.

This study will use spot growth and proliferation in untreated and treated areas to make a statistically sound evaluation of the cut-and-leave suppression method. The study areas will be of sufficient size to provide a realistic approximation of field conditions while providing statistical sound quantitative results to evaluate the suppression method.<sup>1/</sup> It is hypothesized that beetle survival will be reduced, natural aggregation behavior disrupted, dispersal promoted and subsequent tree mortality reduced. If this treatment

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<sup>1/</sup> Clerke, W. H. 1976. The development of field tests for evaluating southern pine beetle control techniques - a preliminary problem analysis.

method is successful, it will provide an effective, low cost, environmentally safe and easy to use technique for landowners with commercially inoperable acreages or limited resources.

State of Knowledge and Expected Outcome. Prior to this study, a great deal of discussion has centered around the use of cut-and-leave as a suppression method. Texas Forest Service analysis of their operational data indicated some promise for the cut-and-leave method (Billings 1974, 1977). In this and additional evaluations in Texas, fewer proliferations occurred around active spots treated with cut-and-leave and salvage than around untreated active spots if treated before October. In Virginia, summer applications of the cut-and-leave method reduced beetle broods (50 to 90 percent) and prevented spot spread (Morris, personal comm.). Winter treatments did not reduce broods, but did seem to disrupt spot proliferation. In North Carolina, there were no significant differences among any of the treatments (cut-and-leave, cut-and-top, untreated) based on proliferations and spot growth (Hertel 1977). This was true for summer and winter treatments.

The cut-and-leave tactic requires that all beetle-infested trees be felled into the center of the spot and a buffer strip (equal to the average height of the pines in the stand) of green pines around the active head of the spot be felled in the same direction (Anonymous 1975).

The rationale underlying cut-and-leave is twofold:

- (1) to reduce beetle populations in the trees by affecting the physical environment (temperature; phloem moisture, and

- (2) to disrupt the growth of the treated spot by causing any emerging beetles to disperse.

The cut-and-leave technique may impose adverse micro-environmental effects on the beetle population. By leaving felled trees' crowns intact, the trees should dessicate faster than do the standing infested trees. The horizontal position should expose the top portion of the stem to a lethal level of direct solar heating. However, when the phloem on the upper portion of felled trees reached 55° C. during the summer, in Texas, beetle survival was only slightly reduced (Palmer 1975). In Louisiana, brood survival was very low for beetles developing on the exposed side of felled infested trees in the summer, fall, and winter (Hodges and Thatcher, 1976). Hertel (1977) found no significant within tree SPB population differences among treatments (cut-and-leave, cut-and-top, check) in a study done in Louisiana one year after Hodge's and Thatcher's study. Ips beetles and sawyers could conceivably better utilize the downed timber, especially if felled pines contained just recently attacking southern pine beetles.

The effect of brood stage was investigated by Hodges and Thatcher (1976) and Ollieu (1969). Hodges and Thatcher found no difference in survival between early brood and late brood trees felled at the same time. However, late broods had smaller brood reductions than early brood trees in Texas (Ollieu 1969).

More important than the attention of the physical environment in the use of the cut-and-leave method is the disruption of spot expansion. The felling of the green buffer strip insures that the secondary attractant-response mechanism has been disrupted. Beetles which survive and emerge from these felled trees will tend to disperse in the absence of aggregating pheromones (Gara, 1967). If the felling is done in the summer when spot expansion is occurring, the physiological conditions of the beetles is such that long range dispersal may not be possible. This dispersal will subject the beetle population to additional mortality.

When attempting to evaluate any new or old control tactic, it is necessary to measure as many variables as possible so one can state reasons for success or failure. In the case of SPB suppression tactics, one can assume that if all infested trees are removed from the woods, treated with insecticides, or piled and burned, the bark beetle population will be reduced to very low levels in the treated spot.

Objective. The objective of this investigation is to measure spot growth and proliferation in treated and untreated areas to evaluate the effect of a southern pine beetle suppression method in reducing SPB losses under conditions closely approximating operation application. The cut-and-leave method will be employed as the treatment. Thus, in addition to meeting its objective, the investigation will provide additional data on cut-and-leave for refining operational application guidelines, developing benefit/cost

cost analysis, and for comparison with the data from newly-developed suppression tactics.

Suppression Evaluation Procedures. The effect of cut-and-leave will be measured by comparing differences in the rate of volume loss in stands where infested trees will be felled and left and in similar untreated stands where no infested trees will be felled. Pine and pine-hardwood stands will serve as treatment units in a paired T-test experimental design. A buffer zone adjacent to the stands included in the study will receive the same treatment as the study stands to simulate application of the treatment over a more extensive area and reduce edge effects. Operational procedures will focus on minimizing differences in acreage, site, forest type, and initial level of infestation of stands selected for each pair.

Work in the initial phases of the study will focus on developing and applying procedures for selecting candidate stands. Boundaries of possible study stands will be transferred to appropriate maps for aerial evaluation when red and fading trees become evident during the spring of 1977. Final determination of the stands to be included in each pair will be made following ground checks of candidate stands in which current infestations have been detected.

At the beginning and end of the treatment period measurements will be made of mortality and treatment-related cutting in the selected stands. During the year following treatment, additional

measurements will be made to assess the residual impact of the treatment (cut-and-leave) on losses within the stands.

Selection of Potential Treatment Stands (May 1, 1977 and December 1, 1977. The selection of the Kisatchie National Forest District(s) for study will be based on the probable beetle population levels (historical records and last season's losses), numbers of possible stands, and completeness of stand records.

Only Districts with a history of SPB problems will be considered. A search will be made of: (1) the Insect and Disease Accomplishment Reporting System (IDARS) data bank compiled from the normal District operational suppression data form (SA 5200-1; Appendix B), and (2) the latest S&PF biological evaluations made on all project Districts. As soon as the District is selected, stand selection will begin.

The computer-based National Forest Continuous Inventory of Stand Conditions (CISC) (Appendix C) will be searched for suitable stands. The data in this system is a summary of compartment prescriptions and a projection of activities that are planned for each stand (Appendix C). The CISC characteristics to be used include:

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|----------------------|------------------------|
| A. Forest type -     | 1. loblolly            |
|                      | 2. loblolly-hardwood   |
|                      | 3. shortleaf           |
| B. Stand condition - | 1. immature sawtimber  |
|                      | 2. immature poletimber |

C. Site Infex -	70+
D. Acreage -	20 to 100
	100 to 200

E. Method of cut - 1. thinning

Basal area, a very important consideration in potential spot growth (Hedden 1976), will be obtained from the raw data sheets found in the District office. The basal area measurements are taken while collecting stand data for the CISC system, but are not put into the system.

Following evaluation of CISC data, visits will be made to the selected District where compartment and stand maps will be obtained. The distribution of the possible study plots will be determined by marking the stands on the compartment maps. With the advice of the timber crews and checks of the Resource Photography, the list of candidate stands will be finalized. With this information available, groups of stands will be established from which pairs might be selected in June - July 1977 and January - February 1978. Two sets of Resource Photography will be obtained and the selected stand boundaries transferred onto them. Selected stands will be field checked to verify those data collected.

Detection, ground checking, treatments (June 1, 1977 to October 31, 1977; January 1, 1978 to April 30, 1978). The areas on the District where potential candidate stands are located will be designated for aerial photo and sketch map surveys.

Each block will be sketch mapped (100%) by an experienced sketch map crew. Data from the sketch map survey will serve as the basis for initial stand selection.

After the SPB spot locations have been marked on the stand maps, the group of all similar stands will be scanned. The priorities for ground checking, within a group of stands, will be based on the similarity in estimated numbers of red and fading trees. Two-man crews will be sent into priority stands where the SPB has been located. The location of the spot in that stand will be verified; the infested trees will be numbered (must have 10 and 50 infested trees) and marked with flagging; and the following data recorded: basal area, species, diameter, height. All previously attacked trees from which the beetles have emerged will be marked with a different color flag. The remainder of the stand will be traversed to identify any additional infested trees. Data will be collected for any additional spots detected. Basal area measurements will be taken to verify stand records.

As soon as a study pair has been selected, the treatment (cut-and-leave) will be randomly assigned to one of the stands and the other stand will be designated as an untreated check. The District will be informed as each pair is selected and the treatment assigned. All costs will be covered by this project. The beetle killed and infested trees and the buffer strip trees (around the active spot) will be considered as SPB related losses. If breakouts

occur, they will be immediately treated. The height and d.b.h. of trees cut will be tallied by spot.

An adjacent zone will be designated at least one-quarter mile to the nearest definable boundary from the perimeter of treatment stands. The adjacent zones will be noted on the aerial photos. All spots located in stands adjacent to treatment stands will be treated. Those spots in stands adjacent to check stands will not be treated.

During the first week in July, August, September, October, and February, March, and April, sketch map surveys will be made and any spots detected in the treatment stands and adjacent stands will be subsequently cut-and-left. Volume data will be collected as previously described for any spots treated in the treatment stands during the period from July to November and February to May. No cut-and-leave or other treatment will be applied in either the check or treatment stands for the remainder of the study (Summer evaluation - November 1977 to December 1978 and Winter evaluation - May 1978 to December 1978). This will give us an opportunity to evaluate the carry-over effect of the previous season's treatments.

In November 1977, February 1978, May 1978, and November 1978 (as done in June 1977), sketch map surveys will be made in the untreated and treatment stands. These flights will be coordinated with ground data collection. Ground survey crews will traverse each treatment and check stand, recording data on trees killed since the last examination.

Data Analysis. The procedure outlined in this study is designed to determine if the cut-and-leave treatment of SPB infestations within a stand significantly reduces subsequent SPB caused mortality within the stand. With the data from this study, we will be able to express mortality in terms of trees, volume, and acres. Each of these measures will partition the loss between spot expansion or proliferation.

As previously discussed, the pairs of stands will be selected to minimize differences in area, forest cover, and initial number of infested trees. The cut-and-leave suppression technique will be randomly applied to one stand in each pair. Mortality during each measurement period (June-July '77 to November '77, November '77 to May '78, etc.) will be expressed as a percentage of the mortality occurring in the stand since the inception of the study.<sup>5/</sup>

Analysis of the significance of the reduction in mortality attributable to the treatment will be based on a paired T-test of the differences in mortality between the stands in each pair. It is based on a comparison of the differences in mortality for stands in which the treatment was applied and similar check stands in which no treatment was applied. In the current study, one treatment -- cut-and-leave -- will be evaluated.

Currently available experimental data cannot be used to estimate the variation which can be expected in the difference

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Mortality during the Measurement Period

(Infested trees Initially present)+(Mortality during Measurement Period)

between mortality measurements for a series of paired treatment and check stands. However, because we have defined a measurement of mortality that can only take values over a range from 0 to 1, we can compute the maximum variance  $d^2$  for any given number of stand pairs. The maximum variance for a given number of stand pairs will occur when the difference in mortality between the treatment and check stands is 0 for half the pairs and 1 for the remainder.

The minimum detectable mean difference in tree mortality (percent expressed as a decimal) between treatment and check stands, as a function of the number of pairs and the standard deviation of the differences in mortality between pairs, is presented in Table 1. The calculations are based on the probabilities of detecting a treatment difference when one actually exists 9 times out of 10 ( $1 - b = .90$ ), and of falsely detecting a difference when none exists 1 time out of 20 ( $a = .05$ ). For example, if we choose 10 stand pairs, we will be able to detect a 54% mean difference in mortality between treatment and check stands when there is a maximum variation in differences in mortality measurements. In the more likely case, when the standard deviation is .3 (or the variance .09), we will be able to detect a 30.5% mean difference in mortality between treatment and check stands.

Duration. May 1, 1977 to June 1979.

Table 1. MINIMUM DETECTABLE DIFFERENCE,  $\delta^{1/2}$ , BETWEEN THE CONTROL AND TREATED RESPONSE

Sample Size $n$ Pairs	Standard Deviation <sup>2/</sup> of the Differences Between Pairs					
	.1	.2	.3	.4	.5	.5 $\sqrt{\frac{n}{n-1}}$ <sup>3/</sup>
5	.164	.328	.492	.656	.820	.916
6	.143	.286	.428	.570	.713	.781
7	.128	.256	.384	.511	.639	.691
8	.117	.234	.351	.468	.583	.626
9	.109	.217	.326	.434	.543	.576
10	.102	.203	.305	.407	.508	.536
11	.096	.192	.288	.384	.480	.503
12	.092	.182	.274	.365	.456	.476
13	.087	.174	.261	.348	.435	.453
14	.083	.167	.250	.334	.417	.433
15	.080	.160	.241	.321	.401	.415
16	.077	.155	.232	.309	.387	.399
17	.075	.150	.224	.299	.374	.385
18	.072	.145	.217	.290	.362	.373
19	.070	.141	.211	.281	.351	.361
20	.068	.137	.205	.273	.342	.351
21	.067	.133	.200	.266	.333	.341
22	.065	.130	.195	.260	.324	.332
23	.063	.127	.190	.253	.317	.324
24	.062	.124	.186	.248	.310	.316
25	.061	.121	.182	.242	.303	.309

1/ Percent expressed as a decimal, assuming  $\alpha = .05$ ,  $1 - \beta = .90$

2/ 
$$\frac{\Delta}{d} = \sqrt{\frac{\sum (d - \bar{d})^2}{n-1}}$$

3/ Upper bound of  $\sigma_d^2$